



## Case report

## Rupture of the left ventricle due to blunt trauma – A pediatric case study and literature review

V. Scolan PhD<sup>a,\*</sup>, C. Stahl PhD<sup>a</sup>, H. Eysseric PhD<sup>b</sup>, M. Peoc'h MD, PhD<sup>c</sup>, L. Barret MD, PhD<sup>a</sup><sup>a</sup> Clinical Forensic Medicine Department, Grenoble University Hospital, Grenoble, France<sup>b</sup> Pharmacology Laboratory, Grenoble University Hospital, Grenoble, France<sup>c</sup> Anatomopathology Department, Saint-Etienne University Hospital, Saint-Etienne, France

## ARTICLE INFO

## Article history:

Received 21 January 2010

Received in revised form

10 December 2010

Accepted 20 February 2011

Available online 16 March 2011

## Keywords:

Blunt thoracic trauma

Sudden death

Household accidents

Autopsy

## ABSTRACT

Tamponade due to rupture of the chambers of the heart, in particular the left ventricle, after blunt thoracic trauma is described only sparsely in the literature. Most cases involve multiple thoracic trauma following motor vehicle accidents.

We present the case study of a five-year old victim of a household accident, in which two concrete basins apparently fell on him. He died rapidly, despite attempted resuscitation.

The autopsy showed essentially a hemorrhagic extravasation of the diaphragm and mediastinum, hemopericardium, and massive damage to the apex of the left ventricle. Pathological exam confirmed the traumatic origin of the cardiac rupture, with no underlying pathology.

We will discuss the mechanisms described in the literature that result in such lesions, the mechanism which we believe most probable in this case, and the importance of background information. In our case study, lack of specific information concerning the accident prevents a definitive conclusion of the exact mechanism that caused this massive trauma particularly due to the fact that the external examination couldn't find any lesion in favor of a thoracic or abdominal traumatism. To our knowledge, in context of a household accident, such an isolated lesion causing almost immediate death has not previously been described in the literature.

© 2011 Elsevier Ltd and Faculty of Forensic and Legal Medicine. All rights reserved.

## 1. Introduction

According to the Ministry of Health, in France, every day, 2000 children between 0 and 6 years old are victims of household accidents. In 2002, the Ministry of Health recorded three hundred and eight mortalities of children between the ages of 0 and 15 due to household accidents of which 64% were less than 4 years old. Such accidents are rarely the object of medico-legal postmortems. The findings all showed that 80% of household accidents of the children less than 6 years occurred during playtime inside and outside the house.

We will explore a special case study involving a child's death caused by a material structure. In this instance we will show that the death of a child resulting from this structure, in fact a fountain wall, will implicate the liability of a number of parties. It requires an investigation of the cause of death and the circumstances,

particularly in respect to a faulty structure which became a mechanism of death.

## 2. Clinical case study

We will explore the case of a child with a fatal cardiac rupture which is exceptional due to the characteristic of the injury and the circumstances in which it took place; a household accident.

This 5-year-old boy was hit, in an afternoon, by two cast-concrete basins that fell from a fountain, that was comprised of three elements (column and two basins), after climbing in it. His family was alerted by a deaf noise coming from the garden where played the child. Found upright and staggering by his family, he then collapsed. Nobody saw really the accident take place. He was transported to the nearest physician's office where he died soon after despite attempted resuscitation, which consisted in a cardiac massage essentially.

Examination of the premises by the investigators showed that the two upper basins had broken off. Following appraisal by an expert, it appears that the concrete (which was crumbling) broke

\* Corresponding author. Tel.: +33 (0)476 76 55 14; fax: +33 (0)476 76 87 43.  
E-mail address: [VScolan@chu-grenoble.fr](mailto:VScolan@chu-grenoble.fr) (V. Scolan).

**Table 1**

Description of the fountain.

Measures from the ground	Height (meter)	Diameter (meter)
Column	0.60	0.30
Basin	0.20	0.80
Column	0.45	0.15
Basin	0.15	0.60
Column	0.25	0.11
Basin	0.10	0.30
statuette		

following traction after being pulled toward the ground. This suggests that the child climbed onto the first basin and gripped the second basin, causing the foot of the column to break off. The weight of the block (the two upper basins and their column) that fell was evaluated at around 40 kg (Table 1) (Fig. 1).

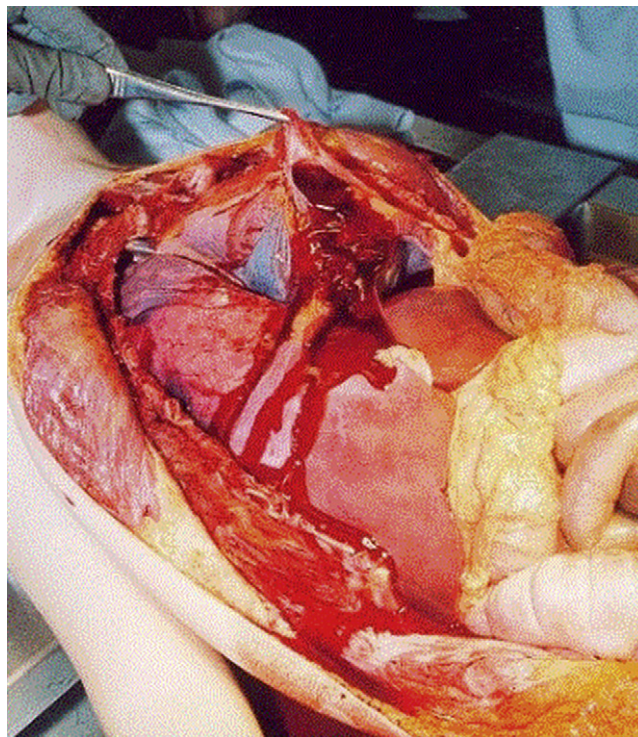
Upon his arrival in the mortuary, the child was naked and No information about clothes carried(worn) at the time of the accident was passed on.

The autopsy showed the following:

- A normal statur-weight development of the child for his age (size 110 cm, weight 23 kg)
- A single external lesion — an ecchymotic scrape next to the lumbar spine, measuring 4.5 cm by 7.5 cm,
- No bone lesions, in particular neither the sternal plastron or the dorsolumbar spine,
- Bilateral pulmonary contusions at the base of each lung and hemorrhagic extravasation in the substernal region of the diaphragm and mediastinum,
- Hemopericardium and massive damage to the left ventricle, but no pericardial lesion. The heart presents an opening along the left edge of the ventricle, being situated in 1 cm over the apex of the myocardium. This opening finds up to the mitral pillar (Figs 2 and 3).

The Pathological evaluation showed the following

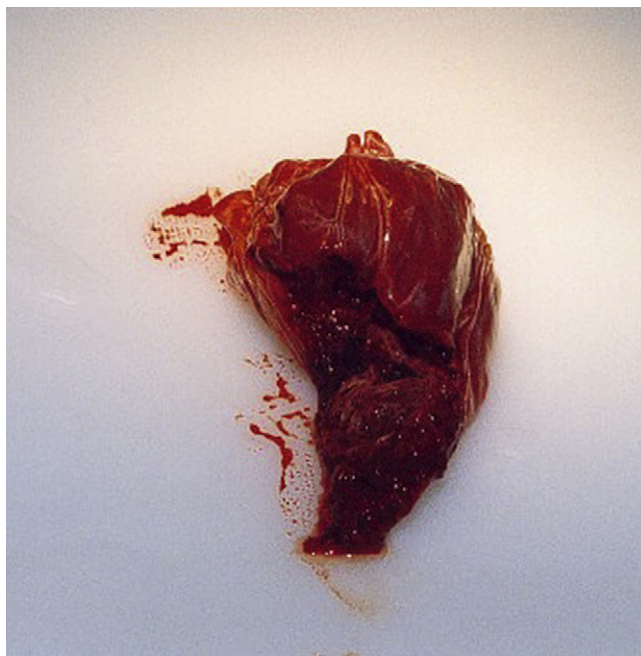
- Heart(80 g): Except the traumatic perforation of the left ventricle, the histology of the heart was normal. Gross and histological examination rule out the presence of other morphological abnormalities.
- Lungs: Intrapulmonary hemorrhage of the right lung with traumatic emphysema.
- Liver, brain, spleen, kidneys were normal.

**Fig. 1.** The fountain after the accident.**Fig. 2.** Massive hemopericardium.

The others organs were normal.

Death followed left ventricular rupture, an injury incompatible with prolonged survival, and which appeared beyond the reach of treatment in view of its extent.

The investigator's findings suggest that the child fell, landing on his back, with possible blunt thoracic and/or abdominal trauma from the upper basins. Because there were no witnesses to the accident, we cannot confirm this hypothesis. Data from previous

**Fig. 3.** Massive damage to the left ventricle.

literature provide several etiological hypotheses for the mechanism of this injury in the context of this blunt trauma.

### 3. Discussion

Cardiac rupture due to blunt trauma in children is rare and has been described most often in autopsy series. Berard reported the first case in 1886: a young boy who died following a fall from a height. The incidence of cardiac rupture in series of blunt thoracic trauma in children ranges from 0.1% to 5%.<sup>2,3,10</sup> Tiao's retrospective study<sup>14</sup> reports an incidence of 0.8%. Mortality rate is extremely high. The literature includes rare cases of survival made possible in part by immediate diagnosis and treatment. According to Calhoon<sup>2</sup> survival is reported in only 5% of cases with cardiac rupture, and only when treatment occurs within 6 h. In all other cases, these injuries are fatal. The majority of deaths occur at the scene of the accident and account for almost half of the cases in some post-mortem pediatric studies.<sup>13</sup> They are rarely isolated and most often associated with other traumatic lesions (to the head, limbs and abdominal organs, as well as pulmonary contusions).

These blunt trauma mainly occur in motor vehicle accidents (passengers, pedestrians). Falls from heights and accidents during sport or games are also reported.

Blunt thoracic trauma can cause injuries to the four chambers of the heart, more or less associated with the great vessels. According to data in the literature (series mainly concerning adults), injuries affect the atria more frequently than the ventricles and the right chambers more often than the left.<sup>3,9</sup> The left ventricle is therefore the chamber least often damaged, but with the highest lethality.<sup>8,9,15</sup> Series of children show the predominance of myocardial contusions, up to 95% for some series,<sup>4,14</sup> and more than 60% in postmortem studies.<sup>13</sup> They are most often associated with injury to other organs, including pulmonary contusions in almost half of cases. Like other authors, Down<sup>4</sup> underlined the low frequency of costal fractures in children (less than 30% of cases) and the absence of external injuries.

Several mechanisms have been described<sup>3,5,10,13</sup>:

- Cardiac rupture due to crushing of the heart between the sternum and the dorsal spinal column (atrial injury when the heart is crushed at end-systole and ventricular injury at end-diastole)
- Cardiac rupture due to a sudden increase in direct intrathoracic pressure from a sudden violent shock to the sternum, or indirect pressure due to a violent shock to the abdomen, causing cardiac injury. Taking into account the increased mobility of organs in the thorax in children, some authors report these cardiac injuries, and more particularly those leading to ventricular rupture via this mechanism, to be more frequent in children<sup>10,11</sup>
- Secondary cardiac rupture, after cardiac contusion
- Secondary cardiac rupture, after endocardial laceration
- Cardiac rupture due to an acceleration/deceleration mechanism

Wang et al.<sup>16</sup> developed an experimental rat model of blunt thoracic trauma and showed that these traumas are always accompanied by cardiac arrhythmia (fibrillation or tachycardia), most often fatal, but not necessarily with a histological lesion. This study also underlines the importance of associated pulmonary lesions (intraparenchymal hemorrhage, atelectasis) when average force is applied to the thorax.

In our case, the lack of witnesses to the accident does not enable us to confirm the exact mechanism that resulted in the extensive damage to the apical area of the left ventricle, the lack of external

injury or bone's injury, or histologic injury. Nevertheless with regard to previous literature we can propose two hypotheses:

- By secondary either to compression of the heart between the sternum and the spine at end-diastole or
- Or by intrathoracic hyperpressure due to direct thoracic shock or indirect abdominal shock. In all cases, the fall from a height by the child with a possible shock on a basin or the ground appears to be the most probable circumstance, even though a German study<sup>16</sup> of 61 subjects who died following a fall from a height showed that cardiac lesions, highlighted in 54% of cases, were found only in falls from 6 m or higher. However, this study only concerned subjects who were at least 13 years of age (age range 13–88), in whom thoracic elasticity is lower or absent.

We determine the mechanism of acceleration and deceleration considering the weak height of fall. But, we cannot totally rule out the possible involvement of the resuscitation maneuvers and external cardiac massage in the massive damage around the wound. But we have not found in the literature any such injuries from external cardiac massage and other resuscitation maneuvers. The cardiac lesions most commonly observed are pericardial hematoma, myocardial contusions and atrial rupture.<sup>1,7,11</sup>

During these accidents, families may seek compensation or to sue liable persons, in criminal or civil courts. In this circumstance the system of indemnity in France is rather contrasting.<sup>6</sup> Families can search particular responsibility of the manufacturer or that of the distributor, if the accident is due to a fault in the product. They can also seek the responsibility of the owner, or of the adults in charge of watching the child. In some cases the liability of medical assistance and intervening doctors can be questioned as the death occurred despite only a few external traumatic lesions. It is therefore necessary to determine immediately the reasons and circumstances of the accident and thus the death. Consequently we see the need for prompt inquiry and forensic investigations. Even if investigations are led, the reasoning of hypothesis is necessary and those responsible may be made from these hypotheses. According to criminal court or civil court, the magistrates will use issued hypotheses and shall translate them into terms of liability.

### 4. Conclusion

This special case (few clinical cases of this type of cardiac lesion in a context of domestic accident can be found in literature) allows us to underline:

- that the lack of external injury or thoracic fracture cannot rule out an underlying traumatic cardiac lesion.
- the potential severity of blunt thoracic or abdominal trauma, due to the morbid character of certain possible cardiac lesions; more especially as the thoracic or abdominal external examination can be normal.
- the importance of performing an autopsy following any "sudden death" of a child or after accidents for both forensic medicine and public health purposes.

Cardiac rupture following thoracic or abdominal trauma is relatively unknown and rarely reported in the pediatric trauma literature. In particular, reports of survival are rare.<sup>8,9,12</sup> These lesions are described most often in autopsy literature, which highlights their morbid character.

*Conflict of interest*

None declared.

## References

1. Bush C, Jones J, Cohle S, Jonson H. Pediatric injuries from cardiopulmonary resuscitation. *Ann Emerg Med* 1996;**28**(1):40–4.
2. Cahloon JH, Hoffman TH, Trinkle JK, Harman PK, Grover FL. Management of blunt rupture of the heart. *J Trauma* 1986;**26**:495–502.
3. Corbi P, Jayle C, Donal E, Rahmati M, Lemaire A, Allal J. Rupture des cavités cardiaques lors de traumatismes fermés du thorax. *Arch. Mal. Coeur* 2001;**94**:1161–5.
4. Down D, Krug S. Pediatric blunt injury: epidemiology, clinical features, and diagnosis. *J Trauma* 1996;**40**(1):61–7.
5. Durak D. Cardiac rupture following blunt trauma. *J Forensic Sci* 2001;**46**(1):171–2.
6. Lambert-faivre Y. In: *Droit du dommage corporel. Système d'indemnisation. Précis de Droit Privé*. 5ème édit; 2004. p. 1045. Dalloz Paris.
7. Hood I, Ryan D, Spitz WU. Resuscitation and petechiae. *Am J Forensic Med Pathol* 1988;**9**:33–7.
8. Mozetti MD, Devin JB, Susselman MS, Lammert GR, Olshaker JS. A pediatric survivor of left ventricular rupture after blunt chest trauma. *Ann Emerg Med* 1990;**19**:386–9.
9. Murillo CA, Owens-stovall SK, Sunghoon K, Thomas RP, Chung DH. Delayed cardiac tamponnade after blunt chest trauma in a child. *J Trauma* 2002;**52**:573–5.
10. Parmey LF, Manion WC, Mattingly TW. Nonpenetrating traumatic injury of the heart. *Circulation* 1958;**18**:371.
11. Price E, Rush L, Perper J, Bell M. Cardiopulmonary resuscitation – related injuries and homicidal blunt abdominal trauma in children. *Am J Forensic Med Pathol* 2000;**21**(4):307–10.
12. Rezende-neto JB, Diniz HO, Filho CS, Abrantes WL. Blunt traumatic rupture of the heart in a child: case report and review of the literature. *J Trauma* 2001;**50**:746–9.
13. Scorpio. Blunt cardiac injuries in children: a post-mortem study. *J Trauma* 1996;**41**(2):306–9.
14. Tiao GM, Griffith PM, Szmuszkovicz JR, Hossein mahour G. Cardiac and great vessel injuries in children after blunt trauma: an institutional review. *J Pediatr Surg* 2000;**35**:1656–60.
15. Turk EE, Tsokos. Blunt cardiac trauma caused by fatal falls from height: an autopsy based assessment of the injury pattern. *J Trauma* 2004;**57**(2):301–4.
16. Wang ND, Stevens MH, Doty DB, Hammond EH. Blunt chest trauma: an experimental model for heart and lung contusion. *J Trauma* 2003;**54**:744–9.